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CH2MHILL

TECHNICAL MEMORANDUM

7/22/99
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6.9.8**Field Reconnaissance of Hanna Stope**

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DATE: July 22, 1999

Purpose and Scope of Work

A reconnaissance trip was conducted on 6 July 1999 into the Bunker Hill Mine in Kellogg, Idaho. Of primary interest are the underground workings of the Russell Adit and Sullivan No. 2 Adit in the Milo Creek Basin area. A large underground opening known as the Hanna Stope is of specific interest for its potential as an underground depository for waste sludge. The sludge is a byproduct from the treatment process of acid mine water that is continually being collected and treated from the underground areas of the mine. Evaluation of this disposal option was identified as a high-priority issue in the Presumptive Remedy Workshop #2 held March 2 and 3, 1999, in Spokane, Washington. The purpose of the underground inspection was to gain a better understanding of the underground conditions, configuration, and characteristics of the Hanna Stope and the associated access adits and shafts so that a better assessment of feasibility and cost of this alternative could be established.

The purpose of this Technical Memorandum is to document the findings of the reconnaissance. The use of this information to evaluate the Hanna Stope as a location for sludge disposal will be presented in a subsequent Technical Memorandum.

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The scope of work for the reconnaissance was previously identified in the Hanna Stope Reconnaissance Plan, prepared by Dave Bunte and Jim Stefanoff (CH2M HILL memorandum dated May 10, 1999). Briefly, the scope of work included the following information-gathering activities:

- Confirm potential locations for plugging the lower portions of the stope for sludge containment. Evaluate plugging method and stress conditions under which the plug must function.
- Determine sources and approximate quantity of water flow into the stope for potential control or diversion.
- Develop an approach for containment and removal of water that accumulates in the stope.
- Determine requirements for cleanup and rehabilitation of the Russell Adit.
- Observe general condition of mine workings with regard to potential improvements for long-term operation and safety.

As part of the work effort, four water quality samples were taken from various levels of the mine during the reconnaissance trip. This sampling effort, and results of analytical testing, will be presented and summarized in a separate technical memorandum.

Personnel

The following people participated in the reconnaissance inspection:

- John Riley – Hydrogeologist
- Bill Hudson – Mining geologist and site safety coordinator
- Willie Lujon - Mine Safety and Health Administration
- Nick Zilka – Idaho Division of Environmental Quality
- Travis Pyle – Civil Engineer CH2M HILL
- Jay Dehner – Geotechnical Engineer CH2M HILL
- Ken Green – Geotechnical Engineer CH2M HILL

Timing and Routes

The inspection trip began the morning of July 6, 1999, and concluded about 6:00 p.m. that evening. Originally scheduled for two days, the trip was condensed into one long day to provide continuity of evaluations and to minimize health and safety concerns.

The team assembled at the site at 8:00 a.m. A safety inspection and brief training of essential safety equipment was held before proceeding into the mine. After the

proper equipment was prepared for use, the team traveled to the Sullivan No. 2 entrance for entry into the mine at 2 Level. The general plan was to inspect the upper levels of the mine first, then work our way down through the various sublevels to the bottom elevation of the Hanna Stope at 6 Level. The objective was to collect as much information as possible about the configuration and condition of the adits, drifts, laterals, and shafts throughout the various levels of the mine in the areas adjacent to the Hanna Stope.

A summary of the reconnaissance route and observation points is presented in Table 1. Figures 1 through 3 (for 2 Level, 5 Level, and 6 Level, respectively) show the routes walked during this reconnaissance trip. The following discussion relates the reconnaissance path and observations at various inspection points along the way.

Mine Entrance at Sullivan No. 2 to Service Raise

The team entered the mine on the east hillside about 100 to 200 feet (vertically) above Milo Creek at the Sullivan No. 2 entrance, located near the confluence with the South and East Forks of Milo Creek. The elevation at the mine entrance is about elevation 3450. Some caving had occurred near the portal area but conditions were dry and entry was judged to be safe.

The heading at the entry was about 30 degrees (azimuth). At a distance of about 150 feet into the adit, we turned onto a downramp that sloped at about a 10 percent grade at a heading of about 130 degrees. We followed this heading for a distance of about 300 feet, where the adit divided into other headings and areas of mine workings. Only minor seepage was encountered into the adit to that point.

From this juncture, we then followed a heading of about 165 to 190 degrees for a distance of about 450 feet to the location of the service raise. The service raise allows ladder access to lower workings and elevations in the mine. Increased seepage was encountered along this section of the adit. The seepage occurred primarily from joints, fractures, and seepage paths in the natural rock mass, but it was concentrated predominantly in certain areas as a result of old borings, raises, and other mine workings. Seepage has been found to correlate well with seasonal changes in quantity of surficial flow in the stream.

The service raise consists of an inclined shaft (approximately 6 x 8 feet) dipping at about 60 degrees from horizontal and at an azimuth of about 220 degrees. The service raise interconnects the Sullivan No. 2 level (approximate elevation 3440) with the various sublevels down to 5 Level (5 Level, approximate elevation 3100). A parallel waste pass also interconnects all sublevels, and currently provides a pathway for water diversions down to 5 Level.

Intermediate Sublevels Between 2 Level and 5 Level along Service Raise

We entered the service raise shaft at 2 Level and progressed down, stopping at selected sublevel areas of the mine where conditions were judged to be safe to get off the ladder and onto the adjacent sublevel bench areas. The ladder at the service raise is constructed of steel rails, supports, and rungs. It shows some signs of scaling and deterioration but was in safe condition for our work.

At several of the sublevels along the service raise shaft, various access laterals were accessible to gain entry around the perimeter and to the edge of the large underground caverns comprising the Hanna Stope. For safety reasons, we could not easily get close to the edge of the stope in many areas. However, we could view the cross-cut openings into the stope, and we could determine the approximate distance across the stope using reflected laser signals from a laser rangefinder targeted at areas on the opposite wall of the stope.

We obtained width measurements where it was possible to gain access to the stope. We also obtained an approximation of the length of the stope area by laser measurements in the stope and along the perimeter mine laterals adjacent to the stope. See Figures 4 through 6 for sketches of the approximate stope configurations and the measurements that were taken.

The Hanna Stope is composed of several openings or caverns in the rock mass. The stope is a large interconnected continuous cavity at 6 Level, but consists of distinctly separate vertical stopes extending up into the rock mass at higher levels. At least one of the stopes is estimated to extend up to about elevation 3400 along the area of the mine workings. Figures 7 and 8 (Sections A and B, respectively) show the arrangement of the stope along its longitudinal axis or strike direction and along an alignment that is perpendicular to the strike.

All of the stopes are inclined at about 60 degrees from horizontal, which is the approximate orientation of the geologic fault that these mine workings follow. The stope is believed to dip to the southwest at an azimuth of about 240 degrees and is arcuate in shape, with the stope extending longitudinally from southeast to northwest (see Figure 3). The stope that was observed at this intermediate level (second sublevel below 2 Level) is believed to be centrally located along the line of stopes that make up the Hanna Stope. This stope broadens out longitudinally into a much larger stope at about elevation 3050 and below, as can be observed at 6 Level (see Figure 7). Above elevation 3050, the stope is believed to be separated by country rock pillars in between the stopes, resulting in several distinctively separate caverns at the upper elevations.

As shown in Figure 4, measurements taken of the central stope area at the second sublevel below 2 Level indicated that the stope was about 135 feet long and was

oriented in a northwest-southeast direction. The width varied from about 90 feet wide at the southeast end to about 50 feet wide at the northwest end of the stope. The average width was approximately 65 feet. This central stope area was found to open both upward and downward at this level. See Figures 7 and 8 for the approximate position and orientation of the stope.

Most of the groundwater observed at the intermediate levels appears to originate from the 2 Level areas. The flow then migrates to the various sublevels via ditches along the bottom of the adits and seepage into joints and fractures, but primarily by drainage down the waste pass to 5 Level. From there, the water flows by gravity along the adits on 5 Level to the Williams Raise, where it then drops to 6 Level, as shown in Figures 2, 3, 5, 6, and 8.

Other drainage areas, such as the Russell Adit, Old and New East Reed Drifts, and others contribute to the total quantity of flow that drops down the Williams Raise to 6 Level. Therefore, the total seepage at this discharge point represents a collection of water from several other areas of the mine, in addition to the seepage that originates in the vicinity of the Hanna Stope. The total flow at the Williams Raise on 5 Level varies seasonally, but was estimated to be about 150 gallons per minute (gpm) during our visit.

A relatively small amount of water presently seeps or drains directly into the stope at some locations along the intermediate sublevels of the mine. In most locations, however, the water has been diverted along the adits to drainage paths (primarily the waste pass) that avoid the stope. Seepage into the service raise was minimal.

5 Level Observations

The bottom of the service raise is at 5 Level, which is also the bottom of the parallel waste pass where most of the groundwater passes from higher levels down to 5 Level. It is also 5 Level that is proposed as the level for the entry of waste sludge into the mine for deposition in the Hanna Stope. As previously discussed, much of the groundwater that seeps and flows from the upper levels of the mine workings is presently collected on 5 Level, where it is routed by gravity flow to the Williams Raise, which is located at the northwest end of the stope. Figures 1 through 6 show the areas of concentrated groundwater flows, flow directions, approximate flow quantities, and locations of drops to lower levels.

At the base of the service raise, a stope was examined near the southeast end of the workings. This stope was located within about 50 feet of the service raise shaft and with a series of measurements was determined to be about 80 feet wide by 100 feet long. The stope also opened both upwards and downwards from 5 Level.

This southeast stope could be examined from several different access points around the perimeter of this cavity. The approximate dip and orientation of the stope could be observed from several of the vantage points at this level. The natural rock was observed to be generally of excellent quality throughout this area of the mine workings. As observed from this level, very little water was found to be entering the stope from 5 Level or from within the stope area.

At Level 5, another stope was observed about 150 feet in a northwestern direction from the southeast stope (see central stope, as labeled on Figure 5). It is believed that all the stopes open up to a common cavity at the base near 6 Level, but that they were not connected at 5 Level (see Figure 7). The central stope area was found to be approximately 210 feet long and distance shots indicated the width to be about 65 feet. This stope also opened both upward and downward from the 5 Level access points. The natural rock quality was excellent in this area and relatively little water was found to be entering the stope from 5 Level or within the stope area. It is believed that other stopes may exist farther to the northwest, but the size or dimensions of these areas was not observed at 5 Level.

From the central stope, we walked in a northwest direction along the east side of the stope area until we reached the Russell Adit. Major flows along this section of 5 Level originate from above the Russell Dam along the Old East Reed Drift, from fracture zones and diamond drill holes along the New East Reed Drift, and from the Old Sullivan workings. All drainage areas gravity flow to the Williams Raise in a northwesterly direction. See Figures 1 through 6 for the areas of concentrated groundwater flows, flow directions, approximate quantity of flow, and locations of drops to lower levels.

At the Russell adit, we walked north for a distance of about 600 feet, where we encountered the ramp that leads down to 6 Level from the Russell Adit. Before continuing down to 6 Level, we walked farther north along the Russell adit until we reached the back side of a cave-in (called out as the "second cave-in" on Figure 2). The second cave-in is estimated to be located about 600 feet into the Russell Adit from the portal.

We inspected the condition of the adit through this section and observed the back side of the cave-in area. The roof of the caved area extended to an estimated height of about 30 feet or more and was judged to be unsafe to enter. It looked as though the top of the caved debris may not extend to the roof of the cavity, and that it may be possible to pass over the top of the cave-in area.

The restoration of the adit would require the repair of the second cave-in area or would require that a new adit be constructed to prepare a path around the unstable areas. It is our understanding, however, that the second cave-in has resulted from

poor-quality rock associated with the Dull fault zone that crosses the adit at this location. Consequently, other potential routes may be just as difficult to re-establish across the fault zone. The poor ground conditions result from associated fracture zones subparallel to the fault and more pronounced rock joint patterns, which lead to the more broken ground conditions, are evident in this area. This area would require more extensive bolts, support mats, and timber cribbing than other areas observed on 5 Level.

6 Level Observations

From the Russell Adit, we walked about 1500 feet down a 10 to 12 percent grade to 6 Level. The heading of this ramp was about 135 degrees near the north end to about 220 degrees near 6 Level workings. We entered the 6 Level workings near the southeast end of the stope, and then worked our way along laterals that parallel the east side of the stope to the northwest. The stope was large and very long at this level. The width of the base of the stope was determined at several of the cross-cut access points to the stope off of the perimeter lateral. The width varied from about 50 feet to 70 feet (see Figure 6). Throughout 6 Level, the stope was found to open upward but not downward.

Entry was not made into the stope area because of safety concerns associated with falling rock debris. Our access for observation of the stope was along the east side. Observation of the condition of the laterals, stope, and groundwater conditions is good along the east side, and nearly all of the approximately 600-foot length of the stope area could be walked and inspected. No access was available to the west side of the stope and the area could not be viewed because of the waste rock piles that remain in the base of the stope.

Rock debris has accumulated in the base of the stope and the waste rock piles were estimated to vary from 20 to 40 feet in height along most of the stope. The rock size of the accumulated material in the base varied greatly along its length. In some areas, the rock waste was relatively fine, with the majority of the material being less than 2 to 3 inches in diameter. In most areas, however, the maximum size of the rock varied from about 1 foot to 6 feet. In one area, a large rock block the size of a house was noted to have fallen to the bottom of the stope and was resting against the inclined face of the stope.

It was noted that the gradation of the rock mass varied so greatly that it would be difficult to construct a filter that was adequately sized to prevent migration of silt-sized sludge fines unless several separate filter layers were used. Construction of such a filter would require starting with a very coarse gradation and building successively finer layers, and would probably require access by earth-moving equipment into the stope to prepare the surface and place the filter material.

Groundwater was being collected from various points along the east lateral and from the stope at 6 Level. Most of the water at 6 Level is collected along various drainage paths leading down from the upper levels of the mine, as previously described. A small portion of this drainage originates directly from fissures or joints in the rock mass.

On the east side of the stope at 6 Level, the water drains by gravity to the northwest along Bunker Hill lateral #6 (see Figures 3 and 6). The water flow at the southeast end of the stope was estimated to be about 25 to 30 gpm and originates from the southeast stope and from the ramp leading down from 5 Level. The flow from the ramp drops down to the Bunker Hill #6 lateral, as shown in Figure 6.

Each of the cross-cut laterals from the stope were estimated to be flowing at a rate of about 10 to 20 gpm, for a combined flow of about 50 to 60 gpm at the northwest end of the Bunker Hill #6 lateral. From the northwest end of the Bunker Hill #6 lateral, the water flow drops into the Van Raise, where it combines with flow from the Williams Raise and possibly other drainage areas along the west side of the stope, where it then drains down to 9 Level. From there, the water flows by gravity to other areas of the mine located farther to the northwest. The estimated combined flow of the Bunker Hill #6 drainage and the flow from the Williams Raise is about 180 gpm.

The east side of the stope is opposite the hanging wall and one might expect to find the greatest accumulations of debris along the base of the inclined wall of the stope. It is our understanding that much of the rock piles that remain at the base of the stope are remnants of the rock that was being mined. Excavators removed the rock from the east side, but would venture only a short distance out into the stope because of safety concerns about falling rock. The debris noted in the bottom of the stope during our visit is, therefore, probably a mixture of the remnants of the rock being mined and additional rock that has fallen since mining has ceased.

Although the debris was noted to be 20 to 40 feet in height in the base of the stope, most, if not all, of the cross-cut access points to the stope at 6 Level are still open. The inside of the stope could be viewed at most of the stope access locations. Although not counted, it is estimated that 12 draw points entered the base of the stope along the east side at 6 Level. Three interconnected cross-cuts lead away from the east side of the stope to a main lateral, with two older cross-cuts continuing to a second parallel lateral located about 100 feet east of the stope. This lateral presently collects water where it is gravity drained to the Mule Raise and eventually down to the Van Raise.

If the stope were to be used for storage of sludge, three cross-cuts and the ramp leading down from 5 Level would have to be permanently plugged to seal off the area where sludge would be stored. The base of the stope should also be drained and provisions for a permanent drainage/water collection system should be incorporated into the design for plugging these cross-cuts as well.

It is our understanding that old mine workings also exist all along the west side of the stope at 6 Level. These workings are no longer accessible because of caved-in areas along the drifts and expansion of the stope into part of the old workings. The drifts and various cross-cut access points to the stope are apparently about 8 feet lower in elevation along the west side of the stope and may have been constructed during more than one period of mining activity. The records of the mine workings along the west side are not complete. Consequently, a good knowledge of the location and extent of the workings and the interconnection of these workings with other drifts and raises that lead down to lower levels in the mine is not available. It is believed, however, that drainage from the west side of the stope exists and is presently connected, via the East Becker Drift, to 7 Level and lower. Other unknown interconnections may also exist.

It is important that these potential connections be identified if sludge is to be stored in the Hanna Stope so that these passages can be adequately filtered and/or plugged. The sludge will be subject to as much as 200 feet of hydraulic water head, and the sludge will readily pipe or erode through voids if such voids exist in the drainages and passageways that lead away from the base of the stope. Because access is not available to the old mine workings along the west side of the stope and little is known about the Hall Raise and interconnected passages from the stope to the Williams Raise, these conditions represent significant unknowns at this time. Additional knowledge can potentially be gained by performing additional exploration, such as making a new drive around the northwest end of the stope from the Bunker Hill #6 lateral to the Williams Raise and possibly to the Hall Raise. The drainage passages would then need to be systematically plugged to contain the sludge. Additional investigation and experimentation by adding water to selected areas of the stope and careful monitoring of the results may provide more information about the possible connection of the west side of the stope with other areas of the mine.

Return to Sullivan No. 2 Entrance and Inspection of the Russell Adit Portal Area

After leaving 6 Level, we returned along the same routes to 5 Level. At 5 Level, we ascended back up to 2 Level via the service raise near the southeast end of the stope area. While climbing back up the ladder, we estimated the vertical distance between the various sublevels below 2 Level as shown on Figures 7 and 8. We did not

attempt to access the third sublevel because of poor access conditions from the service raise. We did, however, stop at the second sublevel and the first sublevel below 2 Level. The Hanna stope was not observed above the second sublevel below 2 Level. We returned to the Sullivan No. 2 Adit entrance via the same route from which we entered the mine.

On the way back down the valley, we stopped at Reed Landing, which is the location of the entrance to the Russell Adit. We inspected the portal area and walked back along the adit to the first cave-in area. We noted that the distance to the first cave-in was about 150 feet from the entrance. The first 130 feet of the adit is concrete encased because of poor-quality rock near the portal area. It was noted that the last panel (130 feet into the mine) had deflected several inches because of external soil pressure and that soil and rock were exposed behind the joints. This area would likely require repair if the adit were to be used in the future. The adit was noted to be about 9 feet wide and about 10 feet in height at the portal.

The first cave-in area appeared to be similar to the second cave-in observed from inside the adit. It is possible that a space exists over the top of the first cave-in but we did not enter because it was not considered safe to enter the caved area. The first cave-in near the portal is associated with poor ground conditions near the surface in that area.

A small area was noted around the portal where materials could be stockpiled. Stockpiling may be required for removal of debris from inside the adits if repairs were to be made. It was estimated that it might be much more cost effective to repair the cave-in areas by excavating the overburden soils at the portal rather than by resupporting the existing adit or making a new drive around the cave-in area. If the overburden soils were to be removed, a substantial area near the portal would be required for stockpiling of rock materials from this excavation. It is our understanding that disposal of the portal overburden material can be done off of the face of the main Reed Landing.

TABLE 1

Routes and Observation Points

		Stope Dimensions/Plugging	Groundwater Diversion	Groundwater Collection & Routing	Access for Sludge Disposal	Condition of Adits	Safety
Enter Sullivan No. 2					•	•	
Walk to Service Raise		•	•		•	•	
Sublevel Inspection	•		•			•	
5 Level Inspection	•	•	•	•	•	•	
6 Level Inspection	•	•	•	•	•	•	
Russell Tunnel Inspection	•	•	•	•	•	•	

Bottom of Service Raise (from 2 Level)

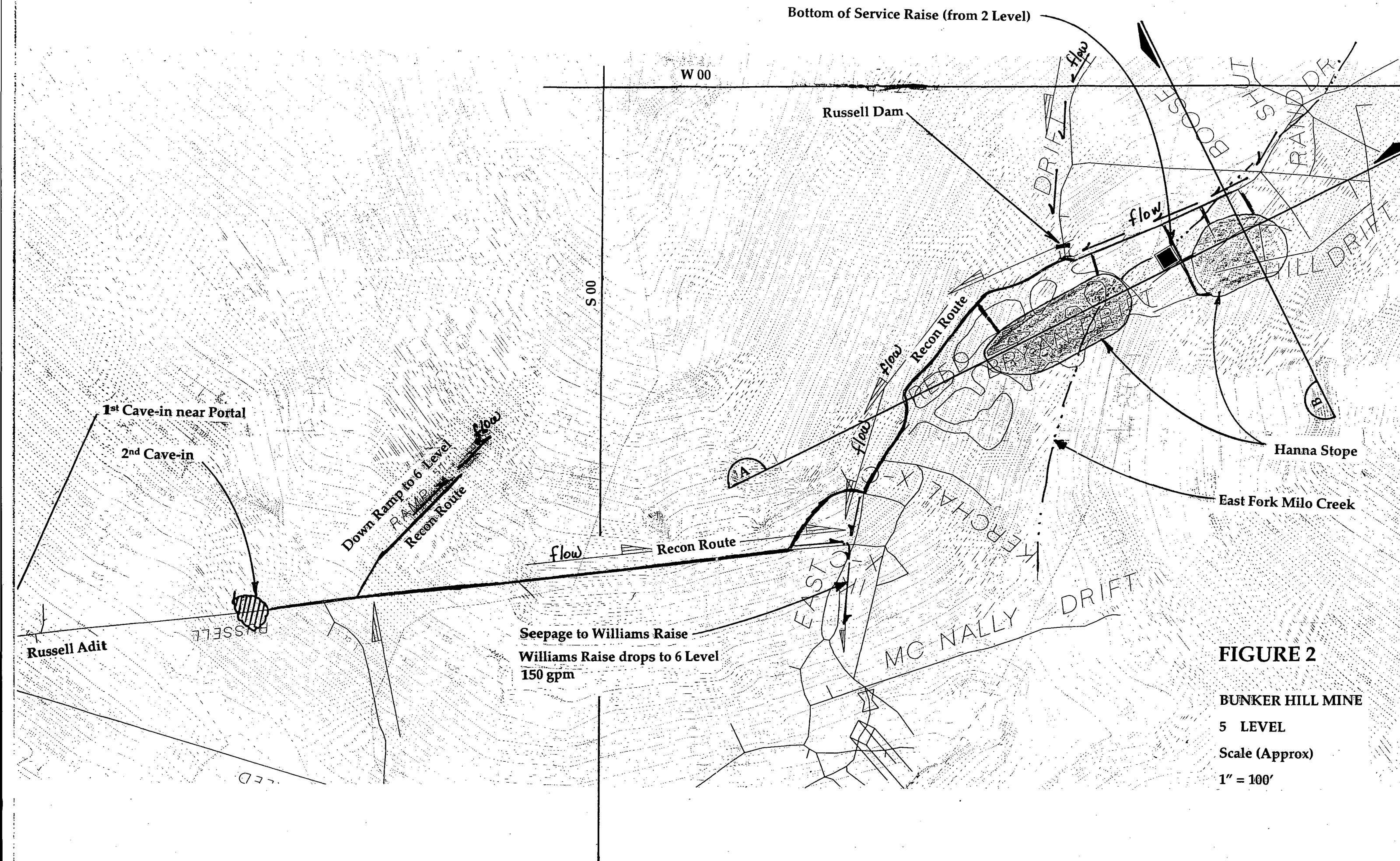


FIGURE 2

BUNKER HILL MINE

5 LEVEL

Scale (Approx)

1" = 100'

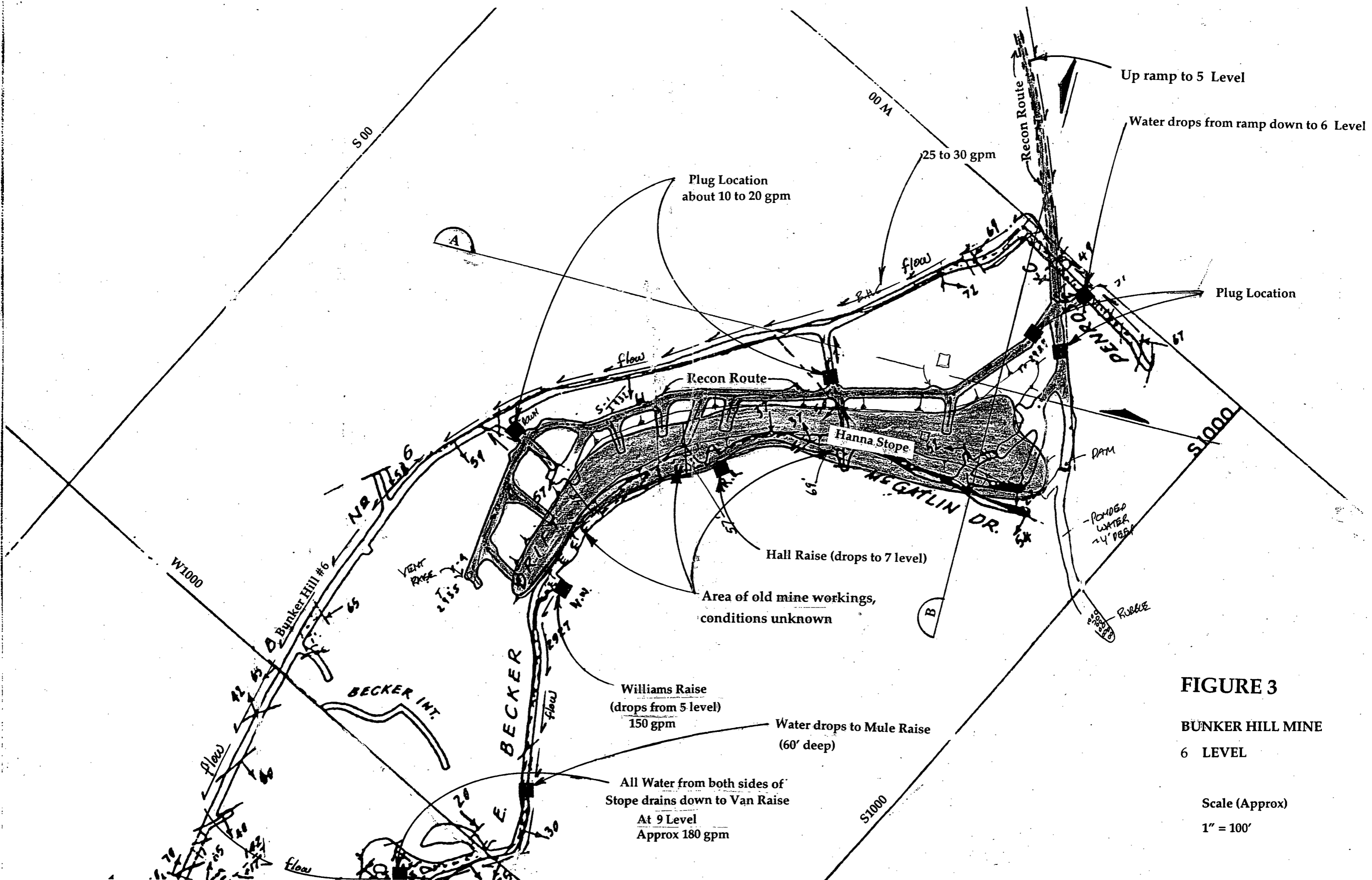
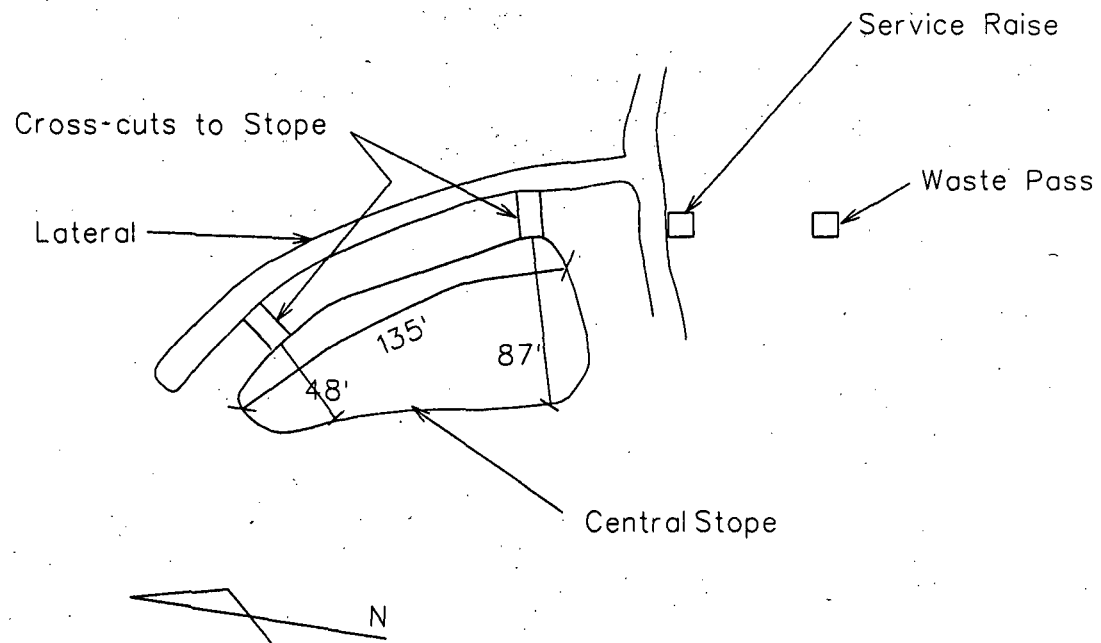


FIGURE 3
BUNKER HILL MINE
6 LEVEL
 Scale (Approx)
 1" = 100'



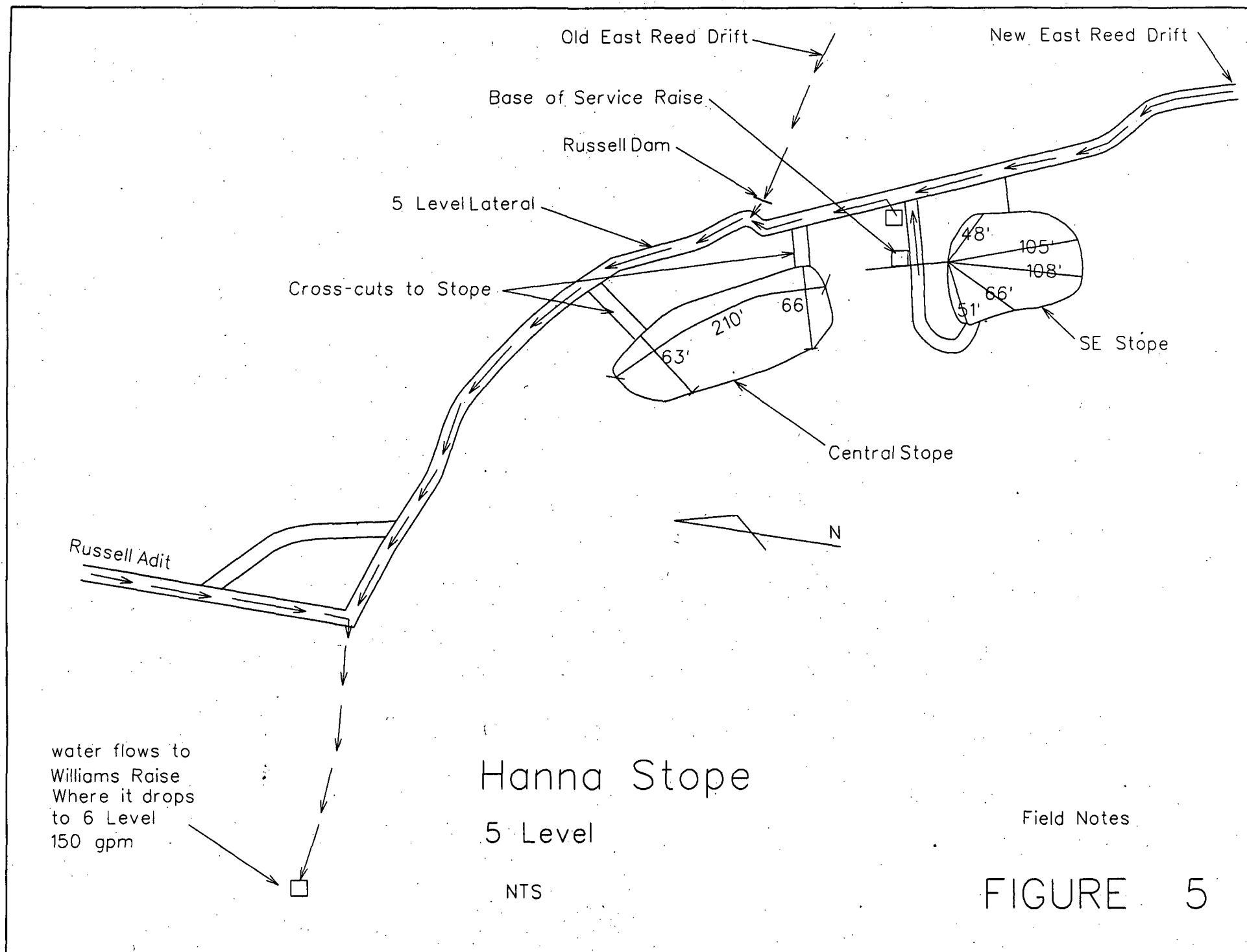
Hanna Stope

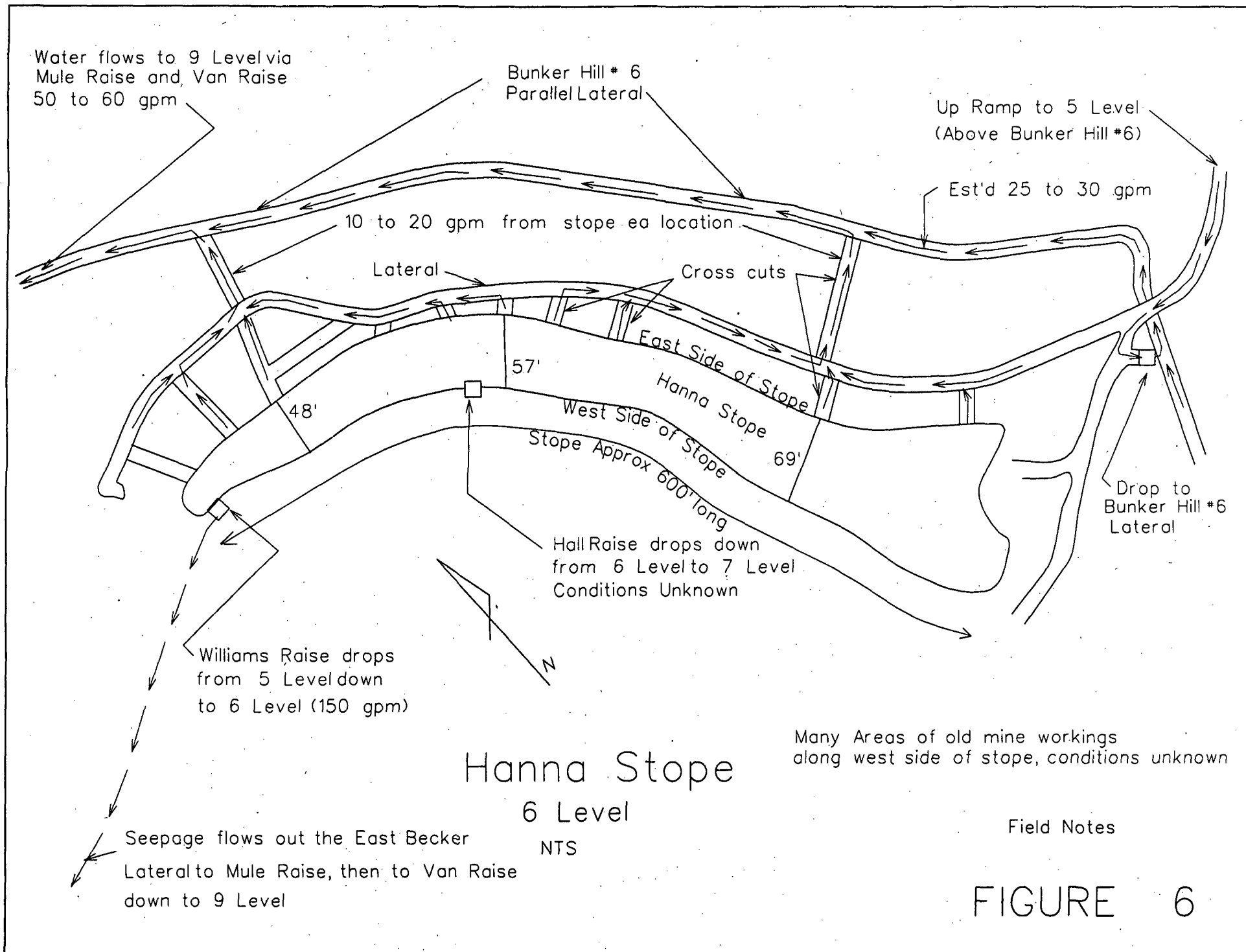
Second Sublevel Below 2 Level

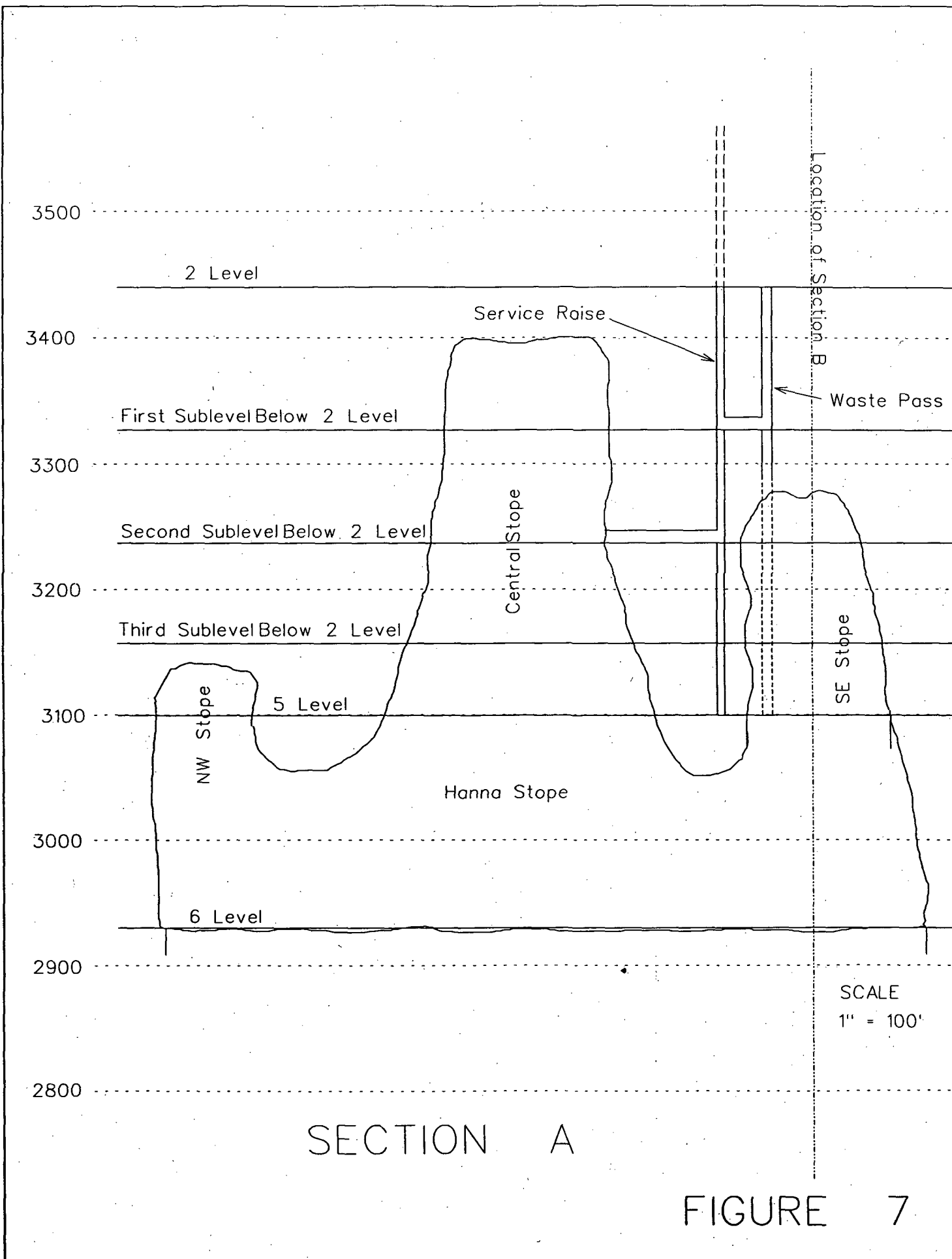
NTS

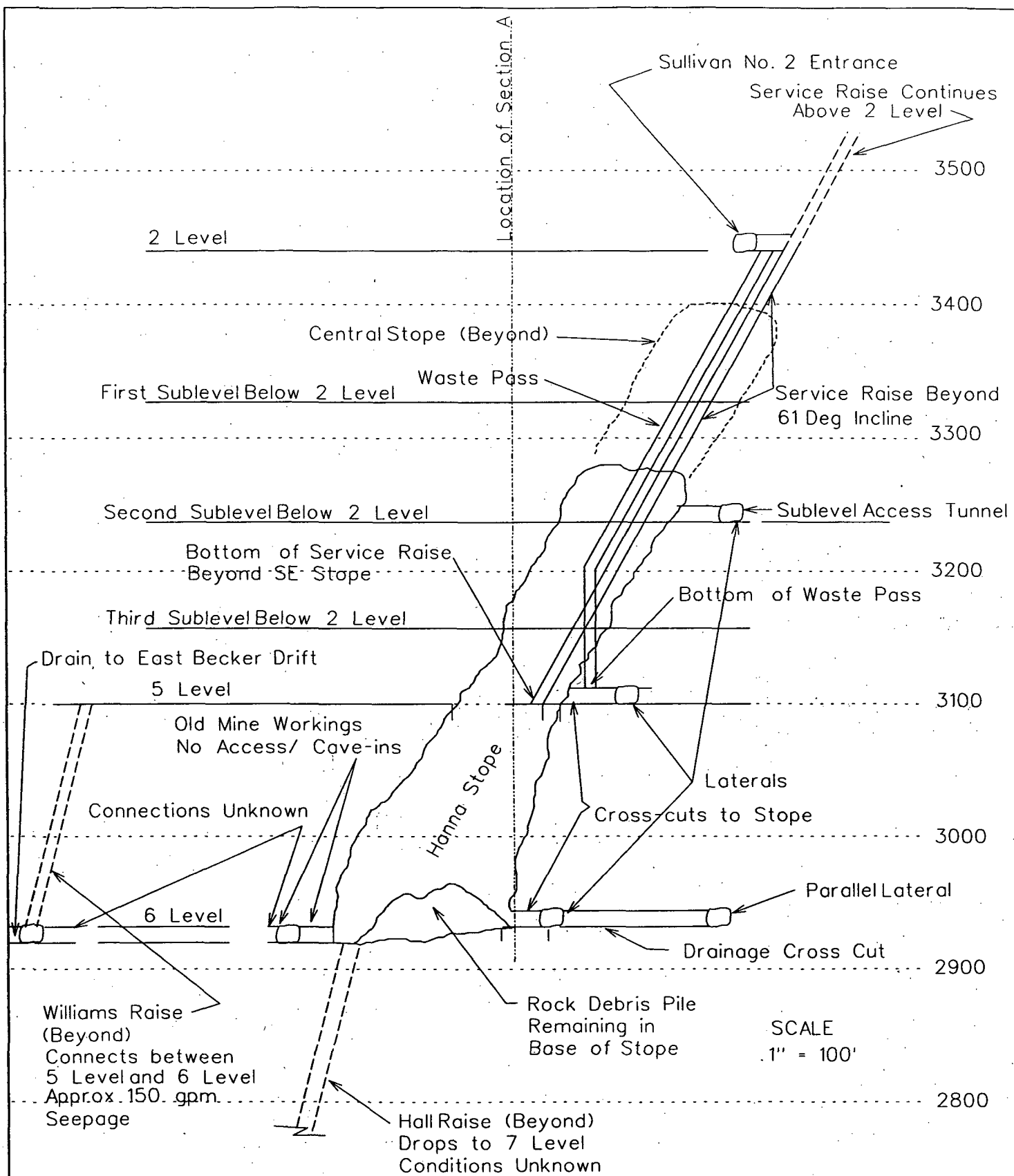
Field Notes

FIGURE 4









SECTION B

FIGURE 8